Hydrography of the Labrador Sea During Active Convection

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LONG-TERM GOALS

To improve our understanding of the dynamics of open-ocean convection and its parameterization in large scale numerical models.

OBJECTIVES

The main objectives are (1) to describe the large scale context in which convection occurs, including the water masses involved and the general circulation, and (2) to characterize the mixed-layer structure and variability, both laterally and vertically, and hence shed light on the nature of the overturning.

APPROACH

A hydrographic data set was collected in winter 1997 as part of the "Deep Convection" Accelerated Research Initiative (ARI). Both CTD and direct velocity profiles were obtained throughout the Labrador Basin, marking the first time that extensive measurements have been obtained during the period of active convection. A two-pronged approach is being taken, with focus both on the large scale and on the detailed mixed-layer structure. Both of these tasks require use of the air–sea flux data collected during the ARI, as well as numerical meteorological products. A model/data collaborative approach is being pursued to investigate the ramifications of convection within a boundary current. Finally, a historical hydrographic/direct-velocity data set from the Irminger and Labrador Seas has been assembled to investigate the spatial distribution of convection within the subpolar gyre.

WORK COMPLETED

A collaborative study with M. Spall (WHOI), investigating various aspects of boundary convection, is now completed and a manuscript has been submitted. This numerical study was motivated by and included observations from the ARI hydrographic data set. My present analysis encompasses both the Labrador and Irminger Seas, investigating local convection in each basin versus spreading of convective waters between the two seas. As part of this analysis I have assembled a hydrographic time series in each basin over the period 1990–1997, which are being used to quantify the circulation and water-mass distribution and variability, both in the interior and on the boundary. Another aspect of this study involves the implementation of a regional advective-diffusive numerical model with M. Spall and K. Lavender (SIO), using data from the ARI palace float program to construct the model velocity field.

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SCIENTIFIC RESULTS

As described in last year's report, one of the exciting revelations from the hydrographic data set was the fact that deep convection occurs along the boundary of the Labrador Sea (*i.e.*, in the Deep Western Boundary Current) as well as in the interior of the basin. This observation helped motivate a numerical study of boundary convection and meridional overturning (Spall and Pickart, 1999). It was found that while water mass transformation can occur throughout the subpolar domain, net sinking (and hence meridional overturning) occurs primarily along the continental boundary. This is a consequence of the fact that constraints imposed by planetary geostrophic dynamics can be relaxed near a boundary, which allows water to sink in conjunction with a lateral pressure gradient along the wall. The ARI hydrographic data support the model results, and were used to estimate the strength of the downwelling near the boundary. The model also suggests that the character of the entire subpolar gyre is sensitive to the presence of such boundary sinking.

Another interesting observation from the ARI hydrographic data was the apparent localization of deep convection to the western side of the Labrador Basin, whereas the palace float velocity data suggests nothing special about the circulation in this region. Furthermore, data from a previous experiment in the early 1990s suggests that convection can also occur in the Irminger Sea. To help investigate what governs the spatial distribution of convection in the subpolar gyre, a time series of hydrographic sections across both the Irminger and Labrador Seas are presently being analyzed. Two different notions are being pursued: (1) that deep convection occurs in the Irminger Basin in analogous manner to that observed in the Labrador Sea, and (2) the spreading of fresh surface waters from the subpolar rim current system strongly controls the locations of deep convection. Evidence of the latter is seen in the mean salinity section across the rim current in the Irminger Basin (Figure 1). The fresh East Greenland current waters are "trapped" to the boundary, which is not the case in the Labrador Sea. The reasons for this, and the associated ramifications, are presently being investigated.

IMPACT / APPLICATIONS

The boundary convection study provided a simple theoretical and numerical framework demonstrating that net sinking within the subpolar gyre should occur primarily along the boundary. The CTD observations of deep convection in the Deep Western Boundary Current gives this idea further credence. This highlights the importance of further study in regions adjacent to topography—both observationally and numerically—to understand further the dynamics associated with sinking. The rim current system also seems to play a crucial role in the spatial patterns of convection, although further analysis is necessary to flesh this out.

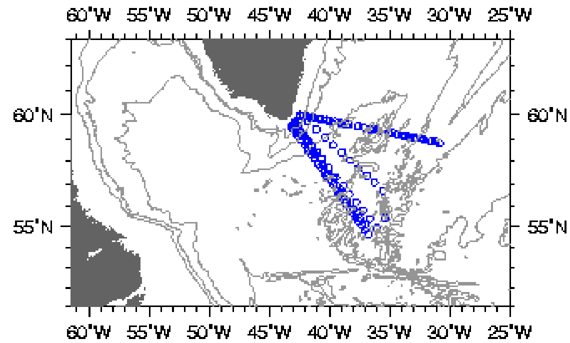
RELATED PROJECTS

This study is part of the Deep Convection ARI. Related projects include drifter studies, air–sea flux and atmospheric circulation studies, and analyses of moored data.

REFERENCES

Spall, M. A. and R. S. Pickart, 1999. Where does dense water Sink? A subpolar gyre example. *Journal of Physical Oceanography*, submitted.

Irminger Basin Sections 1991--1997



Average Salinity (PSU)